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WEATHER MAKING, ANCIENT AND MODERN

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WEATHER MAKING, ANCIENT AND MODERN

BY

MARK W. HARRINGTON

The subject of ancient and modern weather making is a very large one—too large to be treated with entire generality. I shall discuss it rather from the American standpoint, and shall use cases in the Old World simply for the purpose of illustration and for completeness.

Three distinct sorts of weather-making have been employed. The first depends on superstitious and religious methods; then follows on this the degradation of these religious ideas into folk-lore remnants, which have a curious persistency in civilized countries. Both these are psychic. Opposed to them is the third method, mainly American and intensely practical, with which some history and literature are connected.

I. SUPERSTITIOUS AND RELIGIOUS METHODS.

*RAIN MAKING AND STOPPING.**

Many Indian tribes have attempted to produce rainy or dry weather, according to requirements. Among these may be mentioned the Mandan, the Muskingum, the Moqui, the Natchez,

*These cases of weather-making among the North American Indians were collected for me by Dr Fuller Walker, of the Weather Bureau, who searched through the literature available in Washington.

Zuñi, Choctaws, and others. For this purpose pipes were smoked, tobacco was burned, prayers and incantations were offered, arrows were discharged toward the clouds, charms were used, and various other methods were employed. Classifying by tribes the processes employed, we turn first to the Iroquois.

Mrs E. A. Smith, in her "Myths of the Iroquois," says:

> In a dry season, the horizon being filled with distant thunder-heads, it was customary to burn what is called by the Indians real tobacco as an offering to bring rain.
>
> On occasions of this nature the people were notified by swift-footed heralds that the children, or sons, of Thunder were in the horizon, and that tobacco must be burned in order to get some rain. *

As to the Muskingum, Heckewelder, in his "Account of the Indians of Pennsylvania" (Philadelphia, 1819, page 229), says:

> There are jugglers, generally old men and women, who get their living by pretending to bring down rain when wanted, and to impart good luck to bad hunters. In the summer of 1799 a most uncommon drought happened in the Muskingum country (Ohio). An old man was applied to by the women to bring down rain, and, after various ceremonies, declared that they should have rain enough. The sky had been clear for nearly five weeks, and was equally clear when the Indian made this declaration; but about four o'clock in the afternoon the horizon became overcast, and, without any thunder or wind, it began to rain, and continued to do so until the ground became thoroughly soaked.

Heckewelder adds that "Experience had doubtless taught the juggler to observe that certain signs in the sky and in the water were the forerunners of rain."

Among the Natchez, according to Father Charlevoix,† jugglers not only pretended to cure the sick, but also professed to procure rain and seasons favorable for the fruits of the earth. Their incantations were often directed to the dispersion of clouds and the expulsion of evil spirits from the bodies of the afflicted.

In the third report of the Bureau of Ethnology it is stated by J. Owen Dorsey that "When the first thunder is heard in the spring of the year the Elk people [among the Omaha Indians] call to their servants, the Bear people, who proceed to the sacred tent of the Elk gens. When the Bear people arrive one of them opens the sacred bag and, after removing the sacred pipe, hands it to one of the Elk men, with some of the tobacco from the elk

* 2d Ann. Rep. Bureau of Ethnology for 1880–'81 (1883), p. 72.

† Voyage to North America, Dublin, 1776, vol. ii, p. 203.

bladder. Before the pipe is smoked it is held toward the sky, and the thunder god is addressed. * * * 'At the conclusion of this ceremony the rain always ceases, and the Bear people return to their homes.'"*

Catlin, in his "Life among the Indians" (page 78), says that he found that the Mandan had "rain-makers" and also "rain-stoppers," who were respected medicine men "From the astonishing facts of their having made it rain in an extraordinary drought, and for having stopped it raining when the rain was continuing to an inconvenient length." He adds:

> For this purpose, in a very dry time, the medicine men assembled in the medicine lodge, and sitting around a fire in the center, from day to day smoking and praying to the Great Spirit for rain, while a requisite number of young men volunteered to make it rain. Each one of these, by ballot, takes his turn to mount to the top of the wigwam at sunrise in the morning, with his bow and arrows in his hand and shield on his arm, talking to the clouds and asking for rain, or ranting and threatening the clouds with his bow, commanding it to rain. After several days of unsuccessful attempts have passed off in this way with a clear sky, some one more lucky than the rest happens to take his stand on a day on which a black cloud will be seen moving up. When he sees the rain actually falling he lets his arrow fly, and pointing says: "There! my friends, you have seen my arrow go. There is a hole in that cloud. We shall soon have rain enough." When he comes down he is a medicine man. The doctors give him a feast and a great ceremony and the doctor's rattle. When the doctors commence rain-making they never fail to succeed, for they keep up the ceremony until the rain begins to fall. Those who have once succeeded in making it rain, in the presence of the whole village, never undertake it a second time. They would rather give other young men a chance.

A similar account of the Mandan ceremony is given by Mr John Frost, in his book "The Indians of North America" (New York, 1845, page 109). He says:

> It was in a time of great drought that I once arrived at the Mandan village on the upper Missouri. The young and the old were crying out that they should have no green corn. After a day or two the sky grew a little cloudy in the west, when the medicine men assembled together in great haste to make it rain. The tops of the wigwams were soon crowded. In the mystery lodge a fire was kindled, around which sat the rain-makers, burning sweet-smelling herbs, smoking the medicine pipe and calling on the Great Spirit to open the door of the skies to let out the

* "Omaha Sociology," op. cit., 1884, p. 227.

rain. At last one of the rain-makers came out of the mystery lodge and stood on the top of it with a spear in his hand, which he brandished about in a commanding and threatening manner, lifting it up as though he were about to hurl it at the heavens. He talked loud of the power of his medicine, holding up his medicine bag in one hand and his spear in the other; but it was of no use, and he came down in disgrace. For several days the same ceremony continued, until a rain-maker, with a head-dress of the skins of birds, ascended the top of the mystery lodge, with a bow in his hand and a quiver at his back. He made a long speech, for the sky was growing dark, and it required no great knowledge of the weather to foretell rain. He shot arrows to the sunrise and sundown points of the heavens, and also to the north and south, in honor of the Great Spirit, who could send rain from all parts of the sky. A fifth arrow he retained until it was almost certain that rain was at hand. Then, sending up the shaft from his bow with all his might, to make a hole in the dark cloud over his head, he cried aloud for the waters to pour down at his bidding and to drench him to the skin. He was brandishing his bow in one hand and his medicine in the other, when the rain came down in torrents.

Among the Blackfeet Indians, according to W. P. Clark in his "Indian Sign Language" (Philadelphia, 1885, page 72):

The medicine man has a separate lodge, which faces the east. He fasts and dances to the sun, blowing his whistle. He is painted in different colors, and he must have no water, and only after dark can he eat, and then only the inner bark of the cotton-wood tree. A picture of the sun is painted on his forehead, the moon, ursa major, etc, on his body. The dance continues for four days, and should this medicine man drink it is sure to cause rain, and if it [does not] rains no other evidence of his weakness is wanted or taken. He is deposed as high priest at once.

Mr W. Noble of Indian territory says that "The Choctaws, during a severe drought, will fasten a fish to one of their number, who then goes into the water and remains there every day for two weeks in order to cause it to rain." He adds that "In wet weather, if they wish the rain to cease, they go to a sand bank, put sand in a pan, and dry it over a fire."

Among the Moqui, according to Schoolcraft:

There is a charm used for calling down rain. It consists of a small quantity of wild honey wrapped up in the inner fold of the husk of the maize. To produce the effect desired it is necessary to take a piece of the shuck which contained the wild honey, chew it and spit it upon the ground which needs the rain. *

* "History," etc, vol. iii, p. 208.

Captain J. G. Bourke, in his "Snake Dance of the Moqui" (page 120) says:

> There was painted on the east wall a symbolical design, or "prayer," representing three rows of clouds in red and blue, from which depended long narrow black and white stripes, typical of rain, while from right and left issued long red and blue snakes, emblematic of lightning. This was a prayer to the god of clouds to send refreshing rains upon the Moqui crops. * * * Yellow was used in all prayers for pumpkins, green for corn, and red for peaches.

Among the Zuñi, according to Stevenson, medicine sticks were supposed to influence rain. These little sticks are found hidden beneath the rafters of nearly every house in Zuñi.*

Passing a little further from home we find, in Acosta's "History of the Indies,"† some accounts of rain producing and weather making among the Peruvian natives. According to him a Peruvian king in his lifetime caused a figure to be made wherein he was represented, which they called Huáugue, which signifies brother. They carried this image to the wars and in procession for rain or fair weather, making sundry feasts and sacrifices to it. They also pursued other methods. "In matters of importance they offered up alpacas, hanging the beast by the right fore-leg, turning his eyes to the sun, speaking certain words according to the quality of the sacrifice they slew; for if it were of color their words were addressed to the god of thunder and lightning, that they might want no water" (page 341). If they wanted water, to procure rain they set a black sheep tied in the middle of a plain, pouring much chica about it, and giving it nothing to eat until it rained (page 376). This is practiced (says Acosta, 1571–1588), at this day in many places in the month of October.

OTHER WEATHER MAKING.

What precedes relates to rain making or stopping. A somewhat similar series of facts occur among the American Indians concerning other elements of the weather, but their energies in this direction seem to be expended chiefly in the control of the winds.

It appears that the Kansas gens of the Omaha are Wind people, and to them is especially entrusted the control of the

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* 2d Ann. Rep. Bureau of Ethnology, p. 371.

† Hakluyt Society edition, vol. ii, pp. 312–313.

wind. Mr J. Owen Dorsey says the Kanze (Kansa or Kaw) gens of the Omaha tribe, being Wind people, "flap their blankets to start a breeze."* He adds that when there is a blizzard the other Kansa tribe of Indian territory beg the members of the Wind gens to interpose, saying, "O grandfather, I wish good weather. Cause one of your children to be decorated." Then the youngest son of a Kanze man, say one about four feet high, is chosen for the purpose, and painted with red paint. The youth rolls over and over in the snow, reddening it for some distance all around him. This is supposed to stop the blizzard.

The following account is from a book entitled "The Fourteen Ioway Indians" (London, 1844), and relates to raising wind:

> A packet ship, with Indians on board, was becalmed for several days near the English coast. It was decided to call upon the medicine man to try the efficacy of his magical powers with the endeavor to raise the wind. After the usual ceremony of a mystery feast, and various invocations to the spirit of the wind and ocean, both were conciliated by the sacrifice of many plugs of tobacco thrown into the sea; and in a little time the wind began to blow, the sails were filled, and the vessel soon wafted into port.

The Indians also have many associations with thunder. Madam Lucy Elliot Keeler, in a paper recently contributed to the "American Agriculturist" for December, 1892, says:

> The Dakotas used to have a company of men who claimed the exclusive power and privilege of fighting the thunder. Whenever a storm which they wished to avert threatened, the thunder fighters would take their bows and arrows, their magic drum, and a sort of whistle made of the wing-bone of a war eagle, and, thus armed, run out and fire at the rising cloud, whooping, yelling, whistling and beating their drum to frighten it down again. One afternoon a heavy black cloud came up, and they repaired to the top of a hill, where they brought all their magic artillery into play against it; but the undaunted thunder darted out a bright flash which struck one of the party dead as he was in the very act of shaking his long-pointed lance against it. After that they decided that no human power could quell the thunder.

In the "Pawnee Hero Stories and Folk-tales," published by George Bird Grinnell, we find the following:

> An old Pawnee Indian said: "Up north, where we worshipped at the time of the first thunder, we never had cyclones. Down here [Indian territory], now that this worship has been given up, we have them."

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* 3rd Ann. Rep. Bureau of Ethnology, p. 241.

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The Indians in some cases have ideas of controlling the weather more generally, and Dablin, in his "Relation of the Voyages, Discoveries and Death of Father James Marquette,"* writing in 1671–1675, says:

> It now only remains for me to speak of the calumet, than which there is nothing among the Indians [*i. e.*, the Illinois] more mysterious or more esteemed. * * * They esteem it particularly because they regard it as the calumet of the sun, and, in fact, they present it to him to smoke when they wish to obtain calm or rain or fair weather.

Even the control of fog has been attempted, as shown by the following quotation from Dorsey's account of the Turtle subgens of the Omaha:†

> In the time of a fog the men of this subgens drew the figure of a turtle on the ground with its face to the south. On the head, tail, middle of the back and on each leg were placed small pieces of a (red) breech-cloth with some tobacco. This they imagined would make the fog disappear very soon.

But it is not only the pagan Indians who have tried their hand at weather-making. Their christianized descendants have also tried to control these operations of nature. In the transition times between paganism and Christianity occurred some events which throw a curious and instructive side-light on this question, and two of these I will now give.

Mr Parkman says that while the Jesuits labored with the Hurons a severe drougth came upon the fields. The sorcerers put forth their utmost power, and from the tops of the houses yelled incessant invocations to the spirits. All was in vain. A renowned "rain-maker," seeing his reputation tottering under his repeated failures, bethought him of accusing the Jesuits, and gave out that the red color of the cross which stood before their house scared away the bird of thunder and caused him to fly another way. On this a clamor arose. The popular ire turned against the priests, and the obnoxious cross was condemned to be cut down. The Jesuits said: "If the red color of the cross frightens the bird of thunder, paint it white." This was done, but the clouds still kept aloof. The Jesuits followed up their advantage. "Your spirits cannot help you. Now ask the aid of Him who made the world." Heavy rains occurring soon

* Hist. Coll. of Louisiana, part iv, 1852, pp. 34–35.

† 3d Ann. Rep. Bureau of Ethnology, p. 240.

after, it is said that many Indians believed in the white man's Great Spirit and presented themselves to the priests for baptism (Alice Elliot Keeler).

A somewhat similar story is told of Peru by Acosta. It appears that the Santa Cruz Indians became Christians because of the success of a renegade soldier in making rain. This soldier, seeing the native Indians "In a great extremity for water, and that to procure rain they used many superstitious ceremonies, according to their usual manner," said to them that if they would do as he said they should presently have rain, which they willingly offered to perform. "Then the soldier made a great cross, which he placed on a high and eminent place, commanding them to worship it and to demand water, which they did. A wonderful thing to see, there presently fell such an abundance of rain, as the Indians took so great devotion to the holy cross as they fled unto it in all their necessities, and obtained all they demanded, so as they broke down their idols."*

The quotation from Acosta indicates the attitude of the Indians of middle latitudes on this subject. This attitude, as is well known to those familiar with the Latin-American countries, is preserved unchanged among their descendants. Interesting illustrations of it can be picked up any day even as far north as Arizona and New Mexico, and every traveller in Latin-America has several at his disposal. As the quintessence of them all I present a clipping from the *New York Tribune* to which my attention was called by Dr T. C. Mendenhall. *Se non é vero é ben trovato.* The extract runs as follows:

> In the department of Castañas there had been no rain for nearly a year, and the people were brought to such a pass that they were actually dying of thirst, to say nothing of the total destruction of all crops and other agricultural industries.
>
> "El Pueblo Católico," of New San Salvador, prints a number of resolutions promulgated by the principal alcalde of the town and department of Castañas. They are as follows:
>
> "Considering that the Supreme Creator has not behaved well in this province, as in the whole of last year only one shower of rain fell; that in this summer, notwithstanding all the processions, prayers and praises, it has not rained at all, and consequently the crops of Castañas, on which depend the prosperity of the whole department, are entirely ruined, it is decreed:
>
> "Article 1. If within the peremptory period of eight days from the

* Op. cit., vol. ii, p. 524.

date of this decree rain does not fall abundantly, no one will go to mass or say prayers.

"Article 2. If the drougth continues eight days more, the churches and chapels shall be burned, and missals, rosaries, and other objects of devotion will be destroyed.

"Article 3. If, finally, in a third period of eight days it shall not rain, all the priests, friars, nuns, and saints, male and female, will be beheaded. And for the present permission is given for the commission of all sorts of sin, in order that the Supreme Creator may understand with whom he has to deal."

The most remarkable feature of this affair is the fact that four days after these resolutions were passed the heaviest rainfall known for years was precipitated on the burning community.

II. Folk-lore Remnants.*

Among the many curious remnants of folk-lore which we find in connection with the subject of weather making none is more curious than the idea that birds "call for rain." Whenever this expression is used the evident intention is, as is well known to those who are familiar with this mode of speech, to express the idea that they demand the rain, and that rain is likely to follow because of this demand. For instance, the call of the robin, heard so frequently, is interpreted to mean, "Bring out your skillet, bring out your skillet, the rain will fill it." In popular estimation this is a "call for rain." This association with our American robin is very general. In Maine and Massachusetts they are said to "sing for rain" (Miss F. D. Bergen). The American quail is also said to "call for rain," and its cry is interpreted to be, "More wet, more wet" (Dr Robert Fletcher). The call of the loon is given the same meaning in so widely separated localities as Cape Breton, the state of Washington, and Florida (Mr C. A. Smith). The same power is attributed, generally in the Old World, to many other birds, as ducks, geese, crows and ravens. From Pennsylvania (William Schrock) comes the quaint conception expressed in the following rhyme:

The goose and the gander
Begin to meander;
The matter is plain,
They are dancing for rain.

* This series of associations of natural objects with weather-making, in the sense of a weather fetich—a weather maker, not simply a weather forecaster—is taken from the collections of weather proverbs made by the Signal Service and Weather Bureau.

But the birds are not only effective in making rain; they can exert still greater influence. The kildee, or killdeer plover, is said, in Maryland, to call up the wind by his cry of "kildee, kildee!" while to kill him would cause a violent storm (Dr Fletcher). The Kiowa of Indian territory attribute to the killdeer the bringing of spring (James Mooney, Washington).

Another popular association between animals and rain is the idea that by certain treatment of some animals definite results in the way of rain-making can be obtained. For instance, on Santee river, in South Carolina, it is believed that if you catch an alligator, tie him to a tree, and whip him to death it will be certain to bring rain (Dr W. W. Anderson). This seems to be a fragment of negro folk-lore. In Massachusetts it is said that if you see or step on a frog it is a sure sign of rain, while in Maine they say, "Kill a frog and it will rain before morning" (Miss F. D. Bergen). This association of rain with the toad is general over the United States. Still another folk-lore remnant of the same sort relates to snakes. It is a curious fact that among many races the snake is supposed to have some relations with the weather. Mr James Mooney says, "The belief in a connection between rain and snakes is quite general among Indian tribes. The snake dance is intended to bring rain. The Indians of Indian territory turn a dead snake on its back to bring rain." It is a piece of negro folk-lore that hanging a dead snake on a tree will bring rain in a few hours. Further northward it runs "Hang up a snake skin and it will bring rain." This refers to the cast-off skin. In northern Illinois the expression is, "Hang up a snake's cast-off skin on the crab-apple tree and it will bring rain." The snake has played a very important part in weather making, and to it has been attributed many other magical powers.

An interesting series of superstitions with reference to weather making are those which are common to sailors, who have a well known half-serious belief that one can raise wind by whistling. In Newfoundland they say, "Stick a knife in the mainmast and whistle, and it must produce wind." In Newfoundland, also, they have an idea that if a vessel is becalmed wind can be produced by throwing overboard a half-penny. Another notion, common also to the same sailors, is that if you put the end of the sheet overboard it will produce wind, and that if you hit it three times across the thwarts it will stop the rain. Mr

Kinahan, illustrating the sincerity of the belief in the power of whistling in raising wind, says: "In a dead calm you may whistle for wind, except in a dangerous place. Crossing from Skibbereen to Clear island, county Cork, a friend of mine was very nearly getting into a row for inadvertently whistling." This belief is very general. In California sailors say that one may whistle softly for a breeze, but that it is dangerous to indulge in loud or thoughtless whistling, as it may bring a gale. Here the skipper scratches the mizzen-mast for a fair wind.

Sailors profess great confidence in the ability of the cat to raise the wind, and are accustomed to say that the cat carries the wind in her tail. Cats have the general reputation of being very weather-wise. On shipboard especially, it is considered imprudent to provoke a cat, because she is assumed to have a certain share in the arrangement of the weather. Imprudence of this sort appears, however, to have no terrors for the Soudanese in western Java, for, when rain is needed, they form in procession with gongs and clappers, take their cats to the nearest streams, where the animals are sprinkled and bathed.*

Many sailors also have a very curious notion that hen's eggs on board ship produce contrary winds, and on the occurrence of such winds they are likely to insist that the eggs must be thrown overboard.

Another of these folk-lore remnants of sailors is the idea that there is a distinct relation between the albatross and wind. This superstition has been embalmed in most attractive form by Coleridge in his "Lay of the Ancient Mariner." One stanza runs as follows:

> For all averred I had killed the bird
> That made the breeze to blow.
> Oh, wretch! said they, the bird to slay
> That made the breeze to blow.

In addition to the above folk-lore remnants there are some methods which are purely magical. The earliest reference to this sort which I have found is the case of Sópater. He is said to have caused a horrible famine in Asia Minor by "chaining the winds." He was put to death by Constantine—probably for this reason, as this crime was forbidden by the laws of the Twelve Tables as well as later in the Theodosian code.

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* Forbes: Eastern Archipelago, p. 75.

The association of weather making with the witches in Finland is familiar. Steele, in his "Medieval Lore," from Bartholomew Anglicus (about 1260), referring to the people in Finland, says:

> The men * * * occupy themselves with witchcraft, and so to men that sail by their coasts, and also to men that abide with them for default of wind; they prefer wind to sailing, and so they sell wind. They used to make a clue [skein] of thread, and they make divers knots to be knit therein, and then they command to draw out of the clue to three knots, more or less, as they will have the wind more soft or strong; and for their misbelief fiends move the air and arise strong tempests, or soft, as they draweth of the clue more or less knots; and sometimes they move the wind so strongly that the wretches that believe in such doings are drowned by the rightful doom of God.

The elder bush is especially associated with weather making. The witches were thought to make bad weather by stirring water with branches of the elder.

Still another remnant of ancient superstition is, according to Aubrey (1696), to the effect that "On Malvern hills, in Worcestershire, and thereabouts, when they farm their corn and want wind they cry 'Youle! youle! youle!' to invite it, which word, no doubt, is a corruption of Æolus, the god of the winds" (Dr R. Fletcher).

III. Physical Methods.

WEATHER MAKERS.

What precedes relates to purely psychic methods of controlling the weather or the elements. The collection which it presents has been made in no spirit of disrespect, but solely in that of the collection and scientific comparison of facts. I have great respect for all sincere religious belief and great interest in folklore remnants—fragments of what have once been great psychic structures—ruins about the tombs of the ancients. What follows is intensely *fin-de-siècle* and treats of the paradoxer in a well-developed stage. The paradoxer deserves a respect to be measured by the sufficiency of his information and the correctness of his logic. He is a possible benefactor of the world, a potential great man. Galileo was a paradoxer—very unwelcome to the Aristotelians of his time. Kepler was a rank paradoxer to his contemporaries, and Newton was a paradoxer to the Cartesians of his day.

Time will not be spent on rash paradoxers in the field of weather making. We shall only consider those who have some such guarantee as a patent, an appropriation, or genuine learning. As an illustration of the rash paradoxers I will simply mention two, one the man who proposed to destroy blizzards by a line of coal-stoves along our northern boundary from Red river to the continental divide, and the other a man who proposed to ameliorate the weather of New England and the Canadian provinces by damming the strait of Belleisle.

WEATHER MAKING.

We pass first to the treatment for tornadoes. M Weyher has made laboratory tornadoes of a mild and gentle character, but they contain no suggestion as to how to treat this pathologic phenomenon of the weather.

A treatment has been suggested which is heroic and may possibly be effective. It is, however, a local application, and the chief difficulty is to have it ready when and where wanted. The method proposed is that of a great explosion in the tornado itself. Many plans have been suggested, and two patents have been granted. I will consider the first, that of Mr J. B. Atwater, of Chicago (number 370,845, 1887). A strong box with a double bottom is firmly supported on a pole erected at a suitable point, probably a mile or so southwest of the village to be protected. The upper bottom is fixed and the space above it is filled with an explosive and firmly closed. In holes in the upper bottom are inserted fulminating caps and these project below its lower surface. The lower bottom slides up and down. Then, if a high wind drives the lower bottom against the upper with such force as to flash the caps, the explosion follows, and the tornado (if present) suffers the effects which a tornado will suffer when a powerful explosion occurs in its immediate vicinity.

What these effects will be we do not yet know. It is said, with enough repetition to make it fairly worthy of credence, that a cannon fired into a waterspout destroys the latter. If such a disturbance destroys the gentler waterspout, it may be worth while to try a larger one on the more intense tornado. Perhaps it will be effective; we can be more positive when it has been tried.

Many other schemes have been proposed for the control of the elements of the weather. Most of them have an objectionable

side, notably in rain making, which can be pointed out here as well as elsewhere. It is this: The phenomenon to be produced cannot probably be controlled as to area covered, and may occur where it is not wanted. If we are clothing merchants and I carry over too large a stock of winter clothing into late spring, I may order a cold wave to help me reduce my stock. But you may have exhausted your winter stock and wish to have warm weather to start your summer stock. My cold wave affects your trade seriously; I may be sued for damages. Such a state of things is said to have actually happened in Kansas, where a rain maker was refused payment by his employer because of failure of contract, and was sued by a neighbor of the employer because his crops were washed out of the ground. Should the weather maker prosper he will often find himself very much embarrassed until our law makers have caught up with our advance in the arts, and the volume of the statute books has been materially enlarged.

RAIN MAKING.

We come now to the subject of rain making, which has attracted more attention, been more tried, and has more history than any other one method of weather making. It has attained the dignity of at least two patents and two congressional appropriations. A bibliography of the subject is appended, containing 64 titles, two of which refer to books devoted to this subject, respectively by Power and Gathman.

First Method.—To clear the way for the American history we may note here as method number one a French method reported in the *Comptes Rendus* for October 23, 1893. M Baudouin sent a note to the French Academy of Sciences in which he wrote that in Algeria, earlier in that year, he used a kite to obtain electric connection with a cloud at the height of about 4,000 feet. As soon as this connection was made a few drops of rain fell and a local fog formed. These disappeared on breaking the connection, presumably by withdrawing the kite from the cloud. M Baudouin had obtained some rain in Algeria in 1876 by the same method. I know of no other experiments in this direction, nor do they involve anything in opposition to knowledge already acquired. It is a fair field for experiment, and it is remarkable that M Baudouin's experiments have not attracted more attention in the United States.

Second Method.—A second proposed method of obtaining rain is by means of great fires. With this proposal the name of a Pennsylvania meteorologist, James P. Espy, is inseparably connected. In 1841 he published a "Philosophy of Storms," in which he enlarged on this idea previously propounded by him in occasional articles dating from 1838. The idea was not new, for Dobrizhoffer, a Jesuit missionary in South America, in his "Account of the Abipones" (first published in 1784), says that these Indians produce rain by setting fire to the plains. Indeed the idea has been and is generally entertained and in the west has crystallized into the weather proverb, "A very large prairie fire will cause rain." To show something of the character of testimony on which Espy relied we shall quote the story of George Mackay as given in a letter to Espy and printed by him in his "Fourth Meteorological Report" (pages 32–34). Mr Mackay says:

In 1845 I was engaged in the public survey on the Atlantic coast of Florida. Some time in April (the time of the dry season there, which lasts up to June) I was running a township line between latitudes 26° and 27°, about five miles from the sea. The weather was oppressively warm that day. There was not air enough stirring to move an aspen leaf. We found our line must pass through a saw-grass pond, containing about five hundred acres. In ponds of this description the green grass at the top shoots up from five to six feet in height, and when the region has not been for some years swept clear by fires the dead and dry growths of preceding seasons accumulate under the latest growth, and are often found there from two to four feet in depth. They are exceedingly inflammable. When lighted in dry weather they burn with frightful rapidity and violence. Whenever, in our explorations, we came upon a place of this description we could only pass our line by cutting away the lofty fresh grass and wading (or rather wallowing) through the mud and the under rubbish. On the day in question we determined, as it was so hot, that, to save ourselves trouble, we would burn our way through. I had then no thought of your theory. In order to prevent the flames from running over the woods, through which we were obliged to pass, we communicated them at once to both sides of the spot we desired to open, that they might converge and combine in its center and not scatter laterally. In a very few minutes an awful blaze swept over the entire surface which we had marked out for our purpose. We then crossed our line. Ere we had proceeded over forty chains a delightful breeze sprang up and cooled the atmosphere, and presently a refreshing shower sparkled in the bright rays of the sun. All this excited no further observation than that it had not rained there before for a long time. I myself did not observe any smoke nor the formation of any cloud.

Our work went on for some days without a repetition of our short cut at pioneering, some objection having been made when another burning

was proposed, because the first one had rendered it difficult, after crossing the lines, to distinguish the white men from the negroes. At length, however, the pleasant breezes ceased, which had made the weather for a while endurable, and the still air and intense heat returned, and with them constant murmurs from the men, especially the negroes, whose duty it was to cut lines and mark trees. We were now on the confines of a saw-grass pond, and a much more formidable one than any we had yet encountered. Being surrounded by a cypress swamp, we concluded that it had never yet been burned. My assistant, Captain Alexander Mackay, who was standing by my side, mentioned his having, in our late conflagration, observed the formation of a cloud at the apex of the smoke. He added that it had frequently since brought to his mind some account which he had read of Professor's Espy's theory. He suggested that there could not be a better opportunity than this to put the theory to the test, and, being fond of a joke, he said he would like to astonish the superstitious negroes and to make them believe that he could call together the clouds and bring down rain. So we determined to make the experiment.

When our party were all gathered at the halting place complaints of the extreme heat went round and all unanimously agreed that a more confined and oppressive day had never been known to them. To these complaints the usual wishes for "a little breath of air" and "a few drops of rain" succeeded. "Cut through this pond," exclaimed the captain, "and I will bring you more than a few drops of rain; I'll give you a plentiful shower and a breeze, too, that shall wake you up. Come, boys, cut away, and when you've done you shall wash off the dust in a cold bath from the skies!" They stared up and around; not a cloud as large as a man's hand was to be seen, and they looked back at the captain with a good-natured grin of incredulity. "Ho, ho! ha, ha! Captain make cloud out o' nuffin'; he, he! Captain bring water all dis way from de sea? Ho, ho! ha, ha! he, he!" Whereupon the Captain affected to be very indignant. To hasten his victory I ordered the grass to be set on fire. The flames soared forthwith above the tallest trees; a dense volume of smoke mounted upward spirally; the grass soon disappeared; we crossed over. As the smoky column broke and the cloud began to form the Captain traced a large circle in the sand around him, and placed himself in its center, making fantastic figures and forming cabalistic phrases out of broken French. Still was the cloud unnoticed. All eyes were riveted upon the Captain, who stood gazing at the earth and shaping outlines of devils there. At this juncture came a roll of distant thunder. Every glance instantly turned upward; a cloud was spreading there; the thunders increased; the lightnings flashed more vividly; the knees of the negroes shook together with alarm. Already was the rain descending, and in torrents, though the clear sky could be seen in all directions under the cloud. The Captain meanwhile maintained his mystical attitude and continued his wild and extraordinary evolutions. Some of the whites, who were in the secret of the hoax, fell upon their knees, and were imitated by the negroes, whose fears augmenting as the storm grew fiercer, with clasped hands, fastened upon the Captain a stare of

awe and deprecation. In short, the scene presented a more complete triumph of philosophy over ignorance than I could have supposed it possible to have been produced anywhere in the nineteenth century, and most especially anywhere in our enlightened Republic.

We often fired the saw-grass marshes afterward; and whenever there was no wind stirring, we were sure to get a shower; and I say with perfect confidence that we never had a shower in April or May at any other time. Sometimes when there was a breeze, it would carry the smoke toward the horizon, where there would seem to be a fall of rain.

Espy dwelt on this theory with great devotion, and in 1845 published a special letter addressed "To the Friends of Science" in which he proposed a plan for practical rain production. As the paper in question is now very rare and his plan possesses some features of interest, I quote it here:

Let masses of timber to the amount of forty acres for every twenty miles be prepared and fired simultaneously every seven days in the summer, on the west of the United States, in a line of six or seven hundred miles long from north to south; then the following results seem highly probable, but not certain until the experiment is made: A rain of great length north and south will commence near or on the line of fires; this rain will travel eastward; it will not break up till it reaches far into the Atlantic ocean; it will rain over the whole country east of the place of beginning; it will rain only a short time in any one place; it will not rain again until the next seventh day; it will rain enough and not too much in any one place; it will not be attended with violent wind, neither on land nor on the Atlantic ocean; there will be no hail nor tornadoes at the time of the general rain nor intermediate; there will be no destructive floods, nor will the waters ever become very low; there will be no more oppressive heats nor injurious colds; the farmers and mariners will always know before the rains when they will commence and when they will terminate; all epidemic diseases originating from floods and subsequent droughts will cease; the proceeds of agriculture will be greatly increased, and the health and happiness of the citizens will be much promoted. These, I say, are the *probable*—not certain—results of the plan proposed—a plan which could be carried into operation for a sum which would not amount to half a cent a year to each individual in the United States; a plan which, if successful, would benefit in a high degree not merely the landsman, but every mariner that plies the Atlantic. If this scheme should appear too gigantic to commence with, let the trial be first made along the Alleghany mountains; and let forty acres of four ten-acre lots be fired every seven days through the summer in each of the counties of McKean, Clearfield, Cambria, and Somerset, in Pennsylvania; Alleghany, in Maryland; and Hardy, Pendleton, Bath, Alleghany, and Montgomery, in Virginia. The ten-acre lots should be, as nearly as convenient, from one to four miles apart, in the form of a square, so that

the up-moving column of air which shall be formed over them may have a wide base, and thus may ascend to a considerable height before it may be leaned out of the perpendicular by any wind which may exist at the time.

Espy's theory was practically the modern convective theory of storms, and to this most worthy student of science is due the credit of calling effective attention to the part which the condensation of aqueous vapor plays in the mechanism of storms.

Third Method.—Another proposed method of making rain artificially is that of L. Gathman, of Chicago, patented in 1891 (number 462,795). His method is to "Suddenly chill the atmosphere by rapid evaporation, and it is also advisable to produce a heavy concussion in connection with the cooling in order to set the different air-currents in motion. It is obvious that sudden and rapid evaporation in the upper regions of the atmosphere could be accomplished in various ways by the evaporation of various highly compressed gases; but the evaporation consequent upon the release of liquefied carbonic acid gas is thought to be the most efficient." He proceeds:

> In accordance, therefore, with my invention, liquefied carbonic acid gas is liberated in the upper regions of the atmosphere and will, of course, instantly evaporate and spread out in a sheet of vapor of an extremely low temperature and produce a cloud. The surrounding atmosphere will be chilled by its proximity to the cold vapor and the moisture in the atmosphere will be condensed thereby. The condensation takes place in large quantities and with great rapidity, so that a cloud is formed that will precipitate a rainfall upon the earth.
>
> The liquefied carbonic acid gas can be confined in a suitable shell or casing, said casing also to contain an explosive—gunpowder, dynamite, etc—which is thrown or shot into the upper regions of the atmosphere and there exploded by a time-fuse. A balloon, moreover, could be employed to elevate the shell or casing containing the liquefied carbonic acid gas, and the explosion to liberate the gas could be made by an electric current controlled by persons upon the earth.

Mr Gathman also published a little book in which were reproduced, with approval, Professor Newcomb's article entitled, "Can We Make it Rain?" and Professor Houston's "Artificial Rain-making." In this book we learn that Mr Gathman has been occupied with the use of condensed carbon anhydride to cool heavy guns, and was led to his theory by the results of his experiments with ordnance. He also experimented on his method of rain-making, and says (page 38):

In making some experiments last year, a shell filled with liquefied carbonic acid gas was exploded at a height of 600 feet; a cloud was produced in the clear sky at once, and, floating along on a current of air, was visible for miles. This experiment was made in July, 1890, and since that time I have made sufficient other experiments to satisfy myself that I can produce rain whenever necessary, or at will. Experiments made in my astronomical observatory, at a height of only seventy-five feet, have proven that by the evaporation of liquefied carbonic acid gas a rain shower on a small scale can be produced with but a small quantity of the gas. When completed arrangements have been made, the experiments mentioned will be seen to be but a step to the practical illustration on a grand scale.

It appears that in Gathman's method the explosion plays a very subordinate part; but in the method to follow the explosion is the main, if not the only thing.

Fourth Method.—The concussion theory is probably an old one, though it is not correct to refer it to Plutarch, as is sometimes done. In his life of Marius, referring to the battle with the Teutons near Aix, in July, 102 B. C., Plutarch says: "Extraordinary rains pretty generally fall after great battles; whether it be that some divine power thus washes and cleanses the polluted earth with showers from above, or that moist and heavy evaporations steaming forth from the blood and corruption thicken the air, which naturally is subject to alteration from the smallest causes."* Here are two distinct suggestions for rain-making, but not that of concussion.

The first elaborate treatment of the concussion theory appears to have been by Edward Powers, civil engineer, who published in 1890 a book on the relations of battles to rainfall. The first edition was printed in Chicago in 1871, but most of the edition was destroyed by the great fire in that city, which also destroyed the stereotype plates. The latest issue seen by me contains an inset of 15 pages devoted to a criticism of Professor Newcomb's article already mentioned. The aim of this book is to prove that great battles or heavy cannonading are usually soon followed by rainfall. A fair criticism of the book is that such phenomena are not invariably followed by rain. The coincidences could be explained by the fact that in the season of mili-

* Plutarch's Lives, Clough's revision, Am. Book Exchange edition, 1881, pp. 390–391.

tary operations rain is usually falling somewhere in eastern United States; that in fact it is not clear but that the rain is a pure coincidence. The argument is not conclusive. Indeed, it is only fair to say that under the conditions involved it could not be made conclusive. Mr Powers, however, did not despond, but used his utmost endeavors to bring the matter to a test. For this purpose he persuaded Senator Farwell, in 1874, to present a petition to Congress asking that the theory be tried. This, with a previous petition to which he refers, seems to have been without response on the part of Congress.

Later, and apparently independently, the matter was taken up by General Daniel Ruggles, of Fredericksburg, Virginia, who obtained a patent in 1880 (number 230,067) on making rain by explosions in the clouds. His claim runs:

> The nature of my invention consists in sending one or more balloons into the cloud-realms, said balloon or balloons carrying torpedoes and cartridges charged with explosives, and there to explode or detonate them by magneto-electric or electric force through metallic wire, textile cordage, or by the fuse, or by mechanical force, in order to precipitate rainfall by concussion or vibration of the atmosphere.

General Ruggles succeeded in bringing the matter before Congress, but did not succeed in getting an appropriation. His plan was much discussed in the newspapers at the time, but does not seem to have reached the experimental stage.

Senator Farwell, however, continued his interest in the matter, and in 1890 finally succeeded in obtaining an appropriation, first of $2,000, then of $7,000, for carrying on the experiments, some of which he had already had made at his own expense. The appropriation assigned the conduct of the experiments to the Department of Agriculture, and the Secretary selected R. G. Dyrenforth for the work. The experiments were carried on in the vicinity of Washington and in Texas. A report from Mr Dyrenforth was published by Congress in 1892. At the next session of Congress another appropriation of $10,000 was made for this purpose, of which the sum of $4,913.59 was expended, as before, under Dyrenforth's direction, the remainder having been covered back into the Treasury.

Mr Dyrenforth's methods were highly ingenious. He used a variety of explosives, on the ground and in the air, by great single explosions and by volleys. He introduced many novel-

ties, among them that of exploding the gas in the balloon itself when high in the air. His conclusions, as stated by himself in his first report, were (page 59):

> First. That when a moist cloud is present, which, if undisturbed, would pass away without precipitating its moisture, the jarring of the cloud by concussions will cause the particles of moisture in suspension to agglomerate and fall in greater or less quantity, according to the degree of moistness of the air in and beneath the cloud.
>
> Second. That by taking advantage of those periods which frequently occur in droughts, and in most if not in all sections of the United States where precipitation is insufficient for vegetation, and during which atmospheric conditions favor rainfall, without there being actual rain, precipitation may be caused by concussion.
>
> Third. That under the most unfavorable conditions for precipitation, conditions which need never be taken in operations to produce rain, storm conditions may be generated and rain be induced, there being, however, a wasteful expenditure of both time and material in overcoming unfavorable conditions.

His second report has not been published, but I infer that his second series of observations were believed by him to confirm the results of the first.

Mr Dyrenforth generally omitted one check which he might well have employed, and which I personally urged him to employ. Experiments of this sort, made in the free air, with the accompanying conditions not under control, should be accompanied with every possible check; and one self-evident and very necessary one is the observation of a physicist familiar with the meteorologic side of physics. Such an expert (Mr G. E. Curtis) accompanied the party in its first experiments. His report (except the bare meteorologic record made during the experiments) does not accompany Dyrenforth's document. It was presented, however, to the Philosophical Society of Washington, and was printed elsewhere. Mr Curtis says, substantially, that an explosion in a cloud brings down a few scattering drops of rain, and this may happen even with an explosion on the ground, if heavy. Otherwise he says there was no rain-making. It is but fair to say that with Mr Dyrenforth's report are given the reports of his assistants, Mr John T. Ellis, Lieutenant S. A. Dyer, and Mr Eugene Fairchild, and they were stronger in the expression of a belief that rain was successfully made than is Mr Dyrenforth; and there are also many favorable quotations from spectators.

Professor A. Macfarlane, of the University of Texas, was present as an uninvited guest during the elaborate experiments near San Antonio on Friday, November 25, 1892, beginning at 4 p m. The sky was from time to time overcast, and the natural conditions were not unfavorable for rain. Many explosions were made without rain until late in the evening, from which point I will take up the story in Professor Macfarlane's own words, as given in a letter to the *New York World* December 4, 1892:

At 10.15 a balloon was sent up and was lost in the darkness; when it exploded a very large area of light was seen, as if the explosion had occurred inside a cloud. There was no fall of rain at the camp, and nobody was stationed below the spot where the balloon exploded.

I consider this the only experiment that was worth making, yet no care was taken to observe whether rain did fall. It is conceivable that the explosion of a twelve-foot balloon inside a cloud ready to precipitate may jar the particles so as to quicken the dropping of the rain. This was the idea of Ruggles. But to test whether some rain can be drawn down in this manner from a rain-cloud does not suit the ideas of cranks who wish to get a large something out of an absolute nothing.

At 10.45 a mist became just perceptible. The General issued an order to get ready the rain-gauge. The boys hurried up a balloon, which was nearly ready, but it had no effect on that mist.

At 11.40 the mist ceased and the stars appeared in places nearly overhead. The General apparently felt that things were going against him, for he suggested to the Doctor to put a small piece of dynamite in the shells, and also to try the effect of an explosion down at the Springs.

At 12.30 a 12-foot balloon went well into the cloud, but no rain effect.

At 1 o'clock, the time when operations were to be suspended for the night, it was fair, with some stars visible, and the boys were preparing one more balloon. Colonel King remarked that it would be necessary to keep up the operations for forty-eight hours. I retired to a room in the hotel, from which I could see the operations.

At 1.30 I heard a slight shout from the balloon boys, and I could hear the rain pattering on the roof. The General, who had also retired to the hotel, threw open the window and called out:

"Hurry up, boys."

After ten minutes the balloon was exploded, and the rain almost immediately diminished so as to be scarcely perceptible. When the explosion occurred I had my head out of the window. The hotel, a frame house, shook considerably, but there was no breaking of glass or any of the effects produced by a powerful explosion on the solid earth.

At 1.50 the General went out to observe, and I heard him say:

"There is a beautiful rain to the north of us and to the west of us."

At 2 the rain had entirely ceased, and the last of the operations consisted of two shells fired in succession at 2.05.

Professor Macfarlane is a competent physicist. He was trained in Edinburgh and has, I believe, no such appreciation of humor as to make him unconsciously color his report. His conclusions were adverse to the rain makers.

Referring in general to the experiments in Texas, one fact has been generally overlooked. The rainfall in western Texas is always small, but it is subject to its maxima and minima, like other regions. Now, there is a rainfall season in July and August in Arizona and New Mexico, and this reaches western Texas. Thirty percent of the annual rainfall descends in these two months along the eastern border of New Mexico and in the western angle of Texas. At El Paso this percentage is forty. This maximum passes gradually eastward and is found in the southeastern part in September. The experiments in the western part of Texas in 1891 were in September, fairly in the time of this maximum. There is another maximum of rainfall in Texas in November. This is in the northeastern part of the state. The second series of rainfall experiments in Texas was in November, 1892, at San Antonio. The maximum here occurs in September, but there is in November an average (for 24 years) of 2.5 inches, or one-twelfth of the annual 30.6 inches. There is a high relative probability of rain naturally in September in the region of the experiments in 1891, and there is an even chance of it in the region of 1892. To test the theory of rain-making in Texas the months might have been better chosen. Yet it is but fair to say that the rainfall in western Texas is very fluctuating, as it comes generally in local storms.

Fifth Method.—There is another method of rain-making which is still a mystery, but which deserves mention because it has been submitted to actual test. I have not been given permission to use names in this case, and will only guarantee that the letter which I quote came from a high official of a railway company and is worthy of the credence which an official business letter of this sort should carry with it. This gentleman, under date of August 22, 1893, wrote to me as follows:

> Dear Sir: Your letter, August 10, * * * has been referred to me. In reply thereto, we have no published reports concerning rain-making experiments such as mentioned by you. While these experiments have been made by a couple of employés of this company, we can say but little about them ourselves. These parties claimed to be able to cause rainfall by artificial means, and we have furnished them with materials, together

with transportation facilities, more or less all the time since the early part of May, they having experimented in some eighteen or twenty different locations, and in each case we have had more or less rainfall. In nearly every instance we can but feel there is something in their claim. We have had from one-half to three or three and a half inches falls of rain, covering a section of country from twenty-five to ninety miles in length and ten to thirty miles wide, all owing to the direction of the wind, and in some cases at times when there was no moisture in sight or known until they began operations, and then only throughout the section over which their own rainfall extended.

I presume the operators themselves have kept a record of their work, and results of same, at each of the different points where they have been located, and should you desire I will have them make a statement showing what they themselves feel they have accomplished. We have been slow to believe there was anything in this business, but at the same time must admit that they are either very fortunate in reaching the different points where they have experimented just in time to have rain-storms, or they have certainly hit upon the right thing in the way of rain-making.

The process I do not know, but a humorous railway man, personally cognizant of the matter, told me that the operators kept themselves carefully secluded in a freight car with a hole in the roof, and when occasional glimpses were caught of them they seemed to be cooking over a red-hot coal stove. Probably the method employed was that of Frank Melbourne, the Australian, who has most reputation in the west, and who has carefully kept his secret. It is proposed by the company in question to continue the experiments in another field and with competent experts accompanying, and another railroad company is seriously considering the propriety of entering the field.

Conclusions.

Finally, permit me to complete this sketch by some remarks; and, to make them as specific as they can be made, permit me to put them in the form of questions and answers. The answers are my own.

Question. Will a noise make rain? Answer. No; there is no reason in theory or practice to make us think it will.

Q. Will a concussion make rain? A. It will probably jostle the droplets in a cloud and may bring a few together, which may coalesce and become large enough to cause them to fall to the ground—a few scattering drops only.

Q. Will smoke or dust released in great quantities produce

rain? A. Floating particles of spongy texture will absorb the moisture hygroscopically. If the air is dry this will make it drier and prevent rain. If the air is very moist and near saturation, any solid particles in the air will facilitate the condensation; witness the experiments of Aitken and Barus. Thus, when other conditions are very favorable, an addition of much dust or smoke to the air might determine a fall of rain.

Q. Will the expansion of carbon anhydride produce rain? A. Mr Gathman says he has tried it and with success. Experiments should be made systematically.

Q. Will electric connection with a cloud aid in rain formation? A. M Baudouin says it does.

Q. Will a conflagration produce rain? A. Quite probably, under favorable circumstances. It acts in the line in which nature acts, according to the best of our knowledge. Condensation is the result of chilling the air. The theory of chilling by mixture, the Huttonian theory, a century old, is now known to be inefficient. The chilling in nature seems to be due either to the ascent of air and its consequent expansion and loss of heat or the chilling of one cloud by having the shadow of a higher cloud fall on it in sunlight. The chilling by ascent is the method evoked in the Espy plan and appears to be by all odds the most effective rain-producer in nature.

Q. If rain can be made, how much will it cost? A. This is truly an American question, and quite appropriate to the *fin-de-siècle*. Mr Powers, who, by the way, says that Mr Dyrenforth did not after all really try *his* experiment, puts the cost of one experiment with government aid at $80,000. Gathman says he can sprinkle the earth at a cost of from $30 to $90 a square mile. Espy proposed to fire the low forest growths at regular intervals at a cost less than five mills per citizen per year. The method of concussion costs the comfort and peace of all within hearing, a cost which a much more certain result would not justify.

LIST OF REFERENCES TO THE LITERATURE ON THE ARTIFICIAL PRODUCTION OF RAINFALL.

Atwater, John B. Clycone-destroyer: United States patent number 370,845, October 4, 1887; 2 pp., 1 pl.

Abbe, Cleveland. The Production of Rain: Report Maryland State Weather Service, vol. ii, 1892, pp. 64–65.

—. On the Production of Rain: Agric. Sci. State College, Pennsylvania, vol. vi, 1892, pp. 288–309 [Abstract: Amer. Met. Journ., vol. ix, 1892, pp. 312–316; Symon's Met. Mag., London, vol. xxvii, 1892, pp. 129–137, 154–155].

Bell, G. H. A rain Controller: Sci. Amer., New York, vol. xliii, 1880, p. 113.

Bellet, Daniel. La Pluie artificielle dans l'Inde: La Nature, Paris, 23 Avril, 1892, pp. 321–322.

Blake, Lucien J. Can we make it Rain? Science, New York, vol. xviii, 1891, pp. 296–297.

Blunt, W. B. Automatic Tornado-breaker: United States patent number 290,966, December 25, 1883; 2 pp., 2 pls.

Brown, L. L. Automatic Transporter and Exploder for Explosives for aiding Rainfall: United States patent number 473,820, April 26, 1892; 2 pp., 1 pl.

Bruegmann, H. Einwirkung des Kanonendonners auf die Regenbildung: Petermann's Mitth., Gotha, 1862, pp. 439–440.

Curtis, George E. Rain-making in Texas: Nature, London, vol. xliv, 1891, p. 594.

—. Rain-making in Texas: The Inventive Age, Washington, vol. iii, 1891, p. 2.

—. The Facts about Rain-making: Engin. Mag., New York, vol. iii, 1892, pp. 540–551.

Curtiss, G. G. The Production of Rain: Report Maryland State Weather Service, vol. ii, 1892, pp. 63–64.

Davis, W. M. The Theories of artificial and natural Rainfall: Amer. Metl. Journal, Ann Arbor, vol. viii, 1891–'92, pp. 493–502.

Der Einfluss des Krieges auf die Witterung: Illustr. Zeitung, Leipzig, b. ii, 1870, number 1418.

Dyrenforth, Robert G., and Newcomb, Simon. Can we make it Rain? N. Amer. Rev., New York, vol. cliii, 1891, pp. 385–404.

Espy, James P. Artificial Rains [from the National Gazette]: In "Philosophy of Storms," 8°, Boston, 1841, pp. 492–518.

—. To the Friends of Science (on producing rain by artificial means) 8° (Philadelphia), 1845; 6 pp.

—. (Concerning the artificial production of rain). In his Fourth Met. Report: 34th Cong., 3d Session, Senate Ex. Doc. 65, 1857, 4°.

Fernow, B. E. Artificial Rain: Report Secretary of Agriculture, 1890, pp. 227–236.

Gathman, Louis. Method of producing Rainfall: United States patent number 462,795, November 10, 1891; 1 p., 1 pl.

GATHMAN, LOUIS. Rain produced at Will: 8°, Chicago, 1891; 61 pp.

GATTA, L. La Guerra e la Meteorologia. Considerazioni intorno agli effetti dello sparo dell 'artiglieria e della fucileria sullo stato dell'atmosfera: 4°, Roma, 1875.

GUYOT, P. Faut-il tirer le Canon pour avoir de la Pluie? Sci. pour Tous, Paris, t. xvii, 1872, pp. 236–238, 244.

HAZEN, H. A. The Production of Rain: Report Maryland State Weather Service, 1892, vol. ii, pp. 69–70.

—. Rain-making: Sci. Amer., New York, October 31, 1891, p. 277.

HAZEWELL, C. C. Weather in War: Atlantic Mon., Boston, May, 1862, pp. 593–606.

HOUSTON, EDWIN J. Artificial Rain-making: Jour. Franklin Inst., Philadelphia, vol. cxxxii, 1891 (October), pp. 308–315: Sci. Amer. Suppl., number 824, October 17, 1891, p. 13161.

L—. Artificial Production of Rain: Science, Cambridge, vol. iii, 1884, p. 276; La Natura, Milano, vol. i, 1884, p. 270.

LAUGHTON, J. K. Can Weather be influenced by artificial Means? Nature, London, vol. iii, 1870–'71, pp. 306–307.

LA MAOUT, CHARLES. Exposé de la Doctrine des Condensations (Artificial production of rain): 8°, Saint-Brieuc, 1856; 17 pp.

—. Effets du Canon et du Son des Cloches sur l'Atmosphére: 8°, Saint-Brieuc, 1861; 15 pp.

—. Le Canon et la Pluie: 8°, Saint-Brieuc, 1870; 9 pp.

—. Cuirassés, Torpilles et Tempetes: 8°, Cherbourg, 1891; 6 pp.

—. Lettre addressée par Charles LeMaout au "Petit Journal," le 23 Février, 1887. Météorologie (Artificial production of rain): 8°, Cherbourg, 1891; 6 pp.

LE MAOUT, ÉMILE. Lettre à M. Tremblay sur les Moyens proposés pour faire cesser la Sécheresse des six premiers Mois de l'Année, 1870, 8°, n. p. (1891); 16 pp.

LEWIS, J. C. Rain following the Discharge of Ordnance (note to the National Intelligencer, July 25, 1861): Amer. Journ. Sci., New Haven, vol. xxxii, 1861, p. 296; Petermann's Mitth., Gotha, 1862, p. 113.

MACFARLANE, ALEXANDER. On Rain-making (December 31, 1892): Trans. Texas Acad. Sci., Austin, vol. i, 1892–'93, pp. 70–80.

NATION (THE). Rain-makers and Science: The Nation, Oct. 1, 1891, p. 253.

NEWCOMB, SIMON. See Dyrenforth.

NOYES, ISAAC P. The weather Map and the Rain-makers: 8°, Washington, 1892; 46 pp.

Ob die Blitzableiter Gewitter und Regen verhindern und demnach Duerre verursachen können: Schles. Prov.-Bl., Breslau, 1793, number 1.

On great meteorological Changes which have followed violent Engagements in War: Quart. Journal Sci., London, vol. viii, 1871, p. 126.

PICCARD, J. F. Connexion entre le Nombre des Incendies et celui de Jours de Pluie dans le canton de Vaud, pendant la Période de 1840 à 1864: Bull. Soc. Vaud, Lausanne, t. ix, 1866–'68, pp. 167–189.

POTTS, T. H. Rain after Fire: Nature, London, vol. vi, 1872, p. 121.

Powers, Edward. War and the Weather, or the artificial Production of Rain: 12°, Chicago, 1871; 171 pp.; 2d ed., revised, 12°, Delavan, Wisconsin, 1890, 202 pp.

—. Should the rainfall Experiments be continued? A criticism of Professor Simon Newcomb's contribution to the article in the North American Review for October, 1891, entitled "Can we make it Rain?" 12°, Delavan, Wisconsin, 1892, 15 pp.

—. Rain-making: Science, New York, vol. xix, 1892, pp. 52–53.

Production of Rain by human Agency: Sci. Amer. Suppl., New York, vol. iii, 1877, p. 1070.

Rain-makers in India: Sci. Amer. Suppl., New York, October 17, 1891.

Rain-making: Symon's Met. Mag., London, vol. xxvi, 1891, pp. 134–137.

Rowell, G. A. On the Production of Rain at Will: Builder, London' 1880, pp. 265, 298.

—. Artificial Aurora and Precipitation of Rain: 8°, Oxford, 1883. Privately printed.

Ruggles, Daniel. New Method of precipitating Rainfalls: Sci. Amer., New York, vol. xliii, 1880, pp. 106, 342; Les Mondes, Paris, t. li, 1880, pp. 850–851; Année Sci. Indust., Paris, t. xxiv, 1880, pp. 69–71; Cronica Cient., Barcelona, vol. iv, 1881, pp. 53–54.

—. Method of precipitating Rainfalls: United States patent number 230,067, July 13, 1880; 2 pp., 1 pl.

Russell, Robert. Rain produced by Fires: Nature, London, vol. iii, 1870–'71, p. 448.

Schreiber, Paul. Ueber die in Nordamerika angestellten Versuche zur künstlichen Erzeugung von Regen. (A lecture before the Saxon Economical Society, February 10, 1893): Mitth. der Ock. Gesell. im Königr., Sachsen, b. v, 1892–'93, 8°, 22 pp.

Schroepfer, A. Einwirkung des Kanonendonners auf die Regenbildung: Petermann's Mitth., Gotha, 1862, pp. 312–313.

Stone, G. H. Rain-making by Concussion in the Rocky Mountains: Science, New York, vol. xix, 1892, p. 52.

Tice, J. H. Do Battles cause Storms? Amer. Meteorologist, Saint Louis, vol. i (number 6), 1876, pp. 138–145.

Trowbridge, John. Great Fires and Rain-storms: Pop. Sci. Month., New York, vol. ii, 1873, pp. 206–211.

United States Department of Agriculture. Letter from the Secretary of Agriculture transmitting a report of the special agent of the Department of Agriculture for making experiments in the production of rainfall: 52d Cong., 1st Session, Senate Ex. Doc. 45, 8°, Washington, 1892; 59 pp., 9 pls.

Van Bibber, Andrew. Rain not produced by Cannonading: Sci. Amer., New York, vol. xliii, 1880, p. 405.

Walton, J. P. Rain-making: Kansas Academy of Sciences, February 12, 1894, 8°; 3 pp.

Ward, R. DeC. Artificial Rain. A review of the subject to the close of 1889: Amer. Metl. Journal, Ann Arbor, vol. viii, 1891-'92, pp. 484–493.

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